son the work will be of special interest to the plant physiologist. The abstracts used in the preparation of the several monographs have been accurately prepared and the numerous citations to the original literature enhance the value of the work very much. If in courses of plant physiology it were required of the student to isolate all of these plant products it would add very much to the student's competence to deal with the nature of physiological processes and make this subject of greater fundamental value in its application to other phases of botanical work.

The second edition has been improved by re-writing the section dealing with the chemistry of plant pigments. This subject during the past few years has been the field of most interesting study by Willstätter and Miss Wheldale.

The value of the work would be much enhanced by a somewhat different arrangement of the subjects, particularly if they could be connected in their biological relations. To begin with "fats, oils and waxes," substances which are seldom studied in courses in either plant morphology or plant physiology, tend to discourage the use of the book by those for whom it would be a source of greatest benefit. On the other hand if a subject like the carbohydrates or pigments were first considered, both of which are under constant observation by the student of botany, it is quite likely that the chemical methods contained in the work would be applied in laboratory instructions. Furthermore the microchemistry of all of the plant products considered should be considerably improved upon. Many of the statements are only partly true; in others more pronounced reactions could be utilized while in still others a large amount of work should be included. To-day the interest in microchemistry or chemical microscopy is very great and with the appearance of such excellent works as those of Chamot, Molisch and Tunnmann there is an excellent basis in a work of this kind to connect the morphology of plants with the chemistry of the constituent and to follow physiological processes with microchemical reactions.

Henry Kraemer

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SCALARIFORM PITTING A PRIMITIVE FEATURE IN ANGIOSPERMOUS SECONDARY WOOD

Professor Jeffrey, in his recent stimulating book, "The Anatomy of Woody Plants," Ch. VII., derives the vessel with the simple or porous type of perforation from the fusion of horizontal rows of circular pits in the end-wall, the scalariform pit and perforation being merely an intermediate stage in the process. Perhaps such a reversible evolution has gone on in certain groups, although it is here attempted to show that the available evidence is capable of the opposite interpretation.

Multiperforate and even uniperforate end-walls in gymnospermous vessels may arise from the fusion of circular pits with the dissolution of the closing membrane as Professor Jeffrey describes for *Ephedra;* but this fact seems inadequate to explain either the presence of scalariform pitting or the wide prevalence of scalariform perforations in the vascular elements of the less specialized angiosperms. It does not appear that all of the facts germane to the subject have been fully considered. In tracing out the development of vascular elements with uniperforated end-walls in accordance with Jeffrey's hypothesis, serious difficulty is met.

The scalariform pits in conservative regions of the secondary wood of *Liriodendron, Drimys, Asimina,* and other forms with prevailing circular pits in the less conservative regions, suggest antecedence of the scalariform condition, while a further illustration is afforded by the monocotyledonous *Dracæna.* Thus, in *Dracæna aurea,* typical secondary xylem without vessels is formed, the fibro-tracheids of which have circular pits in their lateral walls, but typical scalariform pits in the walls of the overlapping tracheid ends. There is no indication that such scalariform pits have arisen from the fusion of rows of circular pits. They are evidently a primitive feature of the tracheid and closely resemble the scalariform pits of the secondary wood tracheids of *Drimys* found in the vicinity of the pith; yet only a slight modification of the tracheids, with dissolution of the closing membranes and borders of the scalariform pits, would com-

plete transformation into typically perforated scalariform vessels.

It is evident that, to the extent that adjacent cells become specialized, and unlike in shape, in size, and in function, as, for example, the tracheal segment and an adjacent prosenchyma cell of the angiosperms, the scalariform pit must lose its alignment as an intercommunicating structure. Conversely, the circular pit is the more adaptable, and prevails in the vascular elements of more advanced plant families as typified by the Compositæ. Just as might be hypothesized, the scalariform pit is relatively more common in the vascular elements of less specialized families included in the Ranales. Probably the scalariform pit prevailed in the early angiosperms, and is even now being slowly discarded for the smaller circular pit. It was, in case of the vessels, first discarded on the lateral sides adjacent specializing tracheids, ray-cells, wood-parenchyma, or, especially, fibro-tracheids and fibers. The close relation between a vessel and the adjacent element or elements is evident from the fact that, for example, in *Cheirodendron* (Araliaceæ) four distinct types of pits communicate respectively with prosenchyma, wood-parenchyma, ray-parenchyma, and with other vessels. However, that the end-walls should preserve the more primitive sculpture is quite in harmony with the fact that adjacent cells are, in this case, alike. Complex modification is here unnecessary, and adequate comparisons of the secondary wood of existing *primitive* and *specialized* families proves the correctness of the view advanced. It is indeed a remarkable fact that in woods with scalariform perforations in the vessels, the prosenchyma usually bears distinctly bordered pits and is thus less distinct from the tracheal segment than in case of woods in which the vessels are characterized by the simple or porous perforations.

A feature of interest not mentioned by Jeffrey is the more or less frequent occurrence of branched bars. They occur occasionally in *Liriodendron* and other genera with scalariform perforations; but in *Cheirodendron* and some other araliaceous woods this branching of the bars in the perforation may become more or less intricate.

Comparison of such types with the scalariform wood of *Cycadeoidea Dartoni* has been suggested by Dr. Wieland, and for the purpose he has placed before me recently cut sections. The preservation of this fossil is perfect. The sections show the minutest detail in the pitting of the tracheids, even under a magnification of 450 diameters. The outline of the pits, the pit-apertures, and other minute characters are preserved in every detail. The sides and ends of these tracheids, in both tangential and radial aspects, are pitted with regular scalariform bordered pits, which at once remind one of those of *Magnolia*. Along with the true scalariform pits occur a few elliptical pits, and these are inserted between the long pits in such a manner that, by the dissolution of the borders and closing membranes, occasional branched bars would result. The resemblance between the pitting of these cycadeoidean tracheids and the vascular elements of *Magnolia* on the one hand, and of *Dracæna* on the other, is perfect, and may be followed out in minute detail.

The evidence in support of the hypothesis that scalariform pitting is primitive is convincing. It is evident that the process of the breaking up of scalariform pits into circular pits was in progress in the antecedent cycads, and that this process started first in the tracheid side-walls, whereby the overlapping tracheid ends became more conservative than their truly lateral portions. The complementary relations in the wood of the cycadeoids and cycads outlined in Wieland's recent note[1] are thus anatomically reconciled. The origin of branched bars is also explained.

Excellent examples to show that perfect scalariform tracheids exist in living types occur in *Magnolia hypoleuca*. The scalariform pitting very closely approximates that of *Cycadeoidea Dartoni*. Scalariform tracheids slightly more advanced may be found in the aquifoliaceous *Byronia sandwicensis* Endl. Here the tracheids retain typical sca-

1 Wieland, G. R., Feb., 1918, "Cycadoid Wood Structure," *Science*, N. S., XLVII., pp. 141, 142.

lariform bordered pits at the overlapping ends, with the exception that occasional shorter pits are present and in a position to form branched bars should the pit membranes and pit borders be eliminated. The lateral walls show perfect transition from scalariform to circular pits. Living types, therefore, preserve all stages in the transformation of scalariform tracheids into vessels with multiseriate circular pits and simple perforations; and there is every reason to believe that modification is still going on.

Many seem to be under the impression that scalariform pitting is of rare occurrence above the cycads. A close comparison of scalariform tracheids, which Wieland's material makes possible, can leave no doubt that existing forms, in dicotyledons as well as in monocotyledons, still exhibit, in the vascular elements of their secondary wood, almost complete stages in the transformation of scalariform pitting into that of the circular multiseriate type, affording a valuable criterion by which to judge the relative primitiveness of angiosperm groups. The histologic evidence is fairly in accord with the floral evidence.

The exceptional abundance of circular pits in such forms as *Vaccinium corymbosum*, noted by Jeffrey, is accentuated by the fact that, in this type, the vessels are mostly isolated from one another and in contact with wood-prosenchyma which forms circular bordered pits in common with the vessels. Scalariform pitting occurs near the pith where, occasionally, vessels are adjacent. Here occur vessels showing perfectly the transition from scalariform pits to scalariform perforations, as well as the transition stages, noted by Thompson,[2] from scalariform to simple or porus perforations.

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THE ORIGIN OF DICOTYLS

It is generally conceded that the origin of the conifers is from the evolutionary point of view a fairly luminous subject. Neither stem, leaf nor cone has wholly new or remote features. The group appears rather old mainly because so much of its history is known or directly inferable. Evidently, sporophyll consolidation into the hard spiny unisexual cones mainly occurred in the Permian, and by Jurassic time was complete. There is, thus, the distinct connection with the dominant Cordaites of the ancient world, and the cycads and *Ginkgo* amongst still existent types. Moreover, that *Ginkgo* was cosmopolitan, and of varied form in the Rhätic further broadens the possibilities of conifer relationship with known types, while by way of seed-ferns the several gymnosperm lines are in common carried back to Pteridophytes.

Not so the origin of dicotyls, long wholly without the range of scientific discussion. It was understood in a general way that the monocotyls did not obscure the problem. That they were either a contemporaneous or later development appeared more or less certain. Before the discovery of the cycadeoids, however, no line of attack from the viewpoint of either fossil or existent evidence seemed to carry the dicotyls beyond the Cretaceous. Back of that period the decipherable record ceased entirely. But the discovery that the cycadeoids were a varied group with flowers recalling those of magnolias, at once suggested that the origin of the dicotyls could not be wholly obscure. It was soon seen that the great extension of Magnoliaceous species in the lower Cretaceous must indicate a series of more primitive magnolias in the Jurassic. There might have been doubt as to the significance of the cycadeoid flower with its pollen-bearing synangium. But the reduced sorus of existing cycads plainly stood in the complementary relationship, just as did the cycadeoid microsporophyll and the carpellary leaf, as components of cycad fructification.

Nextly it was found by Nathorst and Wieland that the larger proportion of Mesozoic cycadales were cycadeoids, in part bearing small and reduced types of flowers. The *Wielandiella* of Nathorst with its slender bifur-

[2] Thompson, W. P., Jan., 1918, "Independent Evolution of Vessels in Gnetales and Angiosperms," *Bot. Gaz.*, LXV., pp. 89-90.